

**Tomographic Profiling with Energy Dispersive X-Ray Scattering**

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We have been implementing energy dispersive x-ray diffraction (EDXRD) methods for profiling residual strains in structural composite materials (e.g. ceramic coated steel). A number of useful tomographic-like profiling (via x-ray scattering) techniques have been developed as part of this work. In this profiling the incident/diffracted beam and sampling volume are fixed, while the sample is scanned through the scattering micro-volume. The Bragg reflection energies ( $E$ ) and the inter-atomic-plane spacing ( $d_{hkl}$ ) are related by  $E(\text{keV}) = 6.199 / d_{hkl} \sin(\theta)$  where  $2\theta$  is the constant scattering angle. A high-resolution energy-dispersive-Ge detector collects the EDXRD spectra. Figure 1 illustrates some typical EXRD spectra: of the steel and WC/Co coating portions of one of our composites; and of an alumina-titania coating, on steel (inset).

Figure 2 shows a scattered intensity profile (SIP) for a  $\sim 200\mu\text{m}$  plasma sprayed WC/Co coating on a 2.8 mm steel-blank. For the SIP, the net scattered intensity (at all energies) is monitored versus sample position. The steel-substrate and WC/Co-coating are clearly differentiated by virtue of the much higher scattering strength of the high-Z W. In Figure 2-bottom a still more powerful tagged-scattered-intensity-profile (TSIP) method is illustrated for a steel-WC/Co-coated composite. For the TSIP's full EDXRD spectra are collected, versus

specimen position, allowing steel- and WC-specific spectral-features to be "tagged" and integrated separately. Such intensity integration of tagged lines (grouped by lattice-structure/chemical-compound/preferred-crystallite-orientation) provides contrast highlighting of these properties in the tomograph-like profile.

In Figure 3 a reflection geometry scattering schematic is shown, along with a reflection SIP of an alumina-titania coated steel substrate. Points 1-4 in the figure correspond to: (1) the onset of scattering at the ceramic surface; (2) the ceramic interior scattering, with a weak exponential depth-decay; (3) the rapid rise of the scattering at the higher-Z, steel interface; and (4) the rapid exponential decay of scattering in the steel, due to strong absorption.

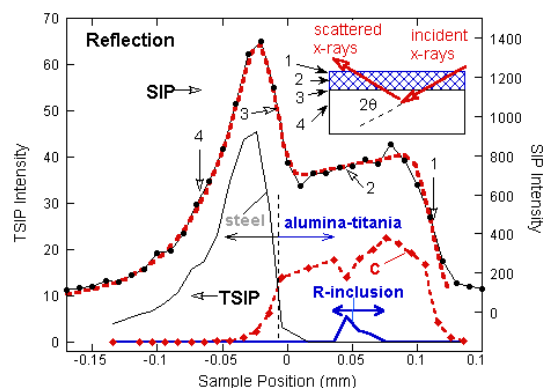


Figure 3. (left) A reflection-mode SIP (solid line) for an alumina-titania coated steel specimen along with a reflection scattering geometry schematic (inset). The dashed red line is a simple scattering-absorption model for a coating thickness of  $124 \pm 1 \mu\text{m}$ . The numbered points are discussed in the text. Also, the separate reflection-mode TSIP curves for steel-scattering, and rhombohedral-(R)- and cubic-(C)-alumina-scattering.

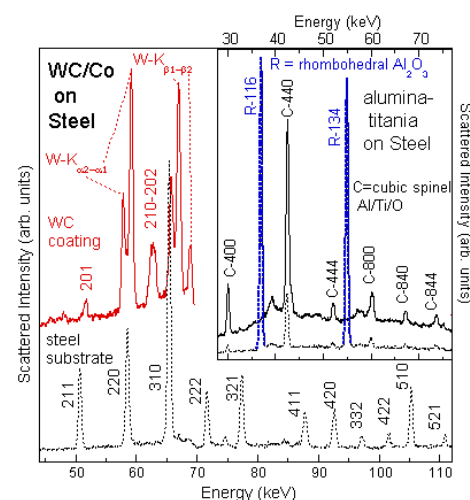


Figure 1. EDXRD spectra for the steel and WC-coating portions of composite specimen. Inset: spectra for an alumina-titania coating with varying mixtures of cubic (C) and rhombohedral (R)  $\text{Al}_2\text{O}_3$ .

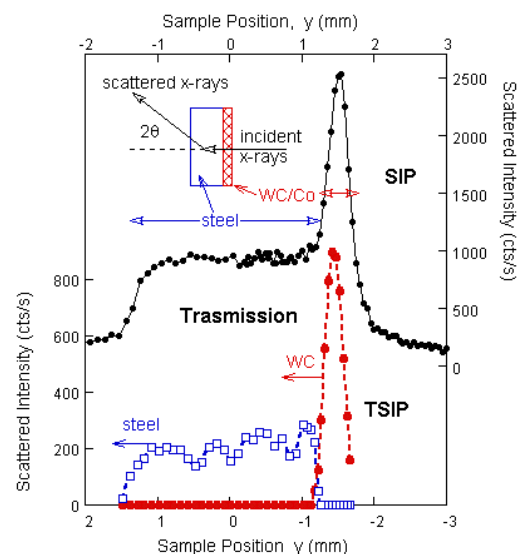


Figure 2. (right) A SIP for a WC/Co coated steel specimen with inset transmission schematic. Also, the "tagged"-SIP (TSIP) spectra for a second WC/Co coated steel specimen